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SECTION OF BIOLOGY[1]

JANUARY 13, 1941

PROFESSOR HORACE ELMER WOOD, 2ND, University of Newark; *Trends in Rhinoceros Evolution.* (This lecture was illustrated by lantern slides.)

It is particularly appropriate that I submit this progress report to the New York Academy of Sciences, since a grant from the Esther Hermann Fund of the Academy, sixteen years ago, was the first outside support for this investigation. More recently, it has been assisted by a grant from the Penrose Fund of the American Philosophical Society.

There is a fable that a publisher once envisioned a definitive book on rhinoceroses. He therefore employed an Englishman, a Frenchman, a German, a Russian and a Pole, each to prepare a suitable manuscript, stipulating the right to publish the best manuscript or to combine excerpts from the several authors. The Englishman disappeared into the wilds of Africa and the Oriental Region, returned with photographs of himself leaning on his gun beside slain rhinoceroses and submitted a manuscript on "How to Hunt Rhinoceroses." The Frenchman, after some

[1] No meeting was held in January by the Section of Geology.

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afternoons spent in the Jardin des Plantes, turned in a short romance, "Les amours des rhinocéros." The German read and partially digested everything that had been published about rhinoceroses and turned in 6,000 manuscript pages under the title, "Ein kurtzes Handbuch der Rhinozeroskunde." The Russian retired to his study with adequate supplies of vodka and tea, and after a few days turned out a philosophical discussion entitled, "The Rhinoceros, does he exist?" And the Pole, after a similar period of isolation, fortified with tea and malinowka, submitted a controversial pamphlet, "Rhinoceroses and the Polish Question." In addition to these aspects, I must omit recognition of the long service of rhinoceros blood, pulverized teeth, horn and other odd parts in the Chinese pharmacopoeia, or the protection of western civilization by cups carved from rhinoceros horn as a sure preventive of, or antidote to poisoning—as long as no poison was used. I shall limit myself to well authenticated data and conclusions, however tempting some of the less established inferences may be, and shall make no attempt to assign personal credit for the various discoveries and generalizations.

The rhinoceroses are generally ranked as a superfamily of the Order Perissodactyla, those hoofed mammals with the mid-line of the foot passing through the third toe. The other living representatives of the order are the tapirs and horses, and the major extinct groups are the titanotheres, chalicotheres and lophiodonts. The living perissodactyls have reached very different stages of evolution. The tapirs are living fossils in an Oligocene stage of evolution, and only the horses may be considered as legitimate participants in the current scene. Of the five living kinds of rhinoceroses, the Sumatran rhinoceros represents a Miocene stage of evolution; the Javan, Indian and black rhinoceroses, various Pliocene stages; and the white rhinoceros would not have been an anachronism in the Pleistocene. Rhinoceroses first appeared in the Eocene, and they have occupied every continent except Australia and South America, and are as common in most of the North American Tertiary as in the old world. The chief evolutionary changes have been in teeth, horns, size and bodily proportions, whereas

the feet and the general character of the skeleton have remained rather stable.

In studying the evolutionary history of the rhinoceroses, we are not merely investigating one more instance of evolution at work, but one which supplies important supplementary information and corrects some current misconceptions. Due to our relatively complete knowledge, the phylogeny of the horse has inevitably come to be the standard textbook example of evolution. Nevertheless, this use has encouraged misinterpretation of the evolutionary process. The phylogeny of the horse is constantly cited to illustrate orthogenesis; that is, using the tree metaphor, the family tree is said to resemble a pine tree with one main stem and insignificant side branches. This has then led further still to the assertion that evolution "usually," or even, "inevitably" proceeds in straight lines, which are thereupon considered as in some Presbyterian fashion predestined or orthogenetic. Again, some particularly spectacular descendant is supposed to be somehow more definitely "predetermined" by the common ancestor than other less interesting issue, like a commercial family tree which shows direct lines of descent from William the Conqueror and Queen Elizabeth culminating in the purchaser. As a matter of fact, the horse family tree is not nearly so simple as it is usually stated to be, as shown even by Matthew's simplified phylogeny, and Stirton's recent phylogeny is still more complex. Although these family trees are anything but monophyletic, it is nevertheless a fact that they are truly simple in comparison with most others. Phylogenetic trees of the giraffes by Colbert, of the North American Canidae by Matthew, and of the higher primates by Gregory show considerably more branching (the diversified adaptation of Darwin or adaptive radiation of Osborn). My rhinoceros phylogeny of several years ago is still more complex, and would be further complicated by recent discoveries. An orthogenetic interpretation of such involved ramification recalls Ouida's messenger who "jumped on his horse and galloped off in all directions." Also, the horses, with their unusually simple family tree, and the rhinoceroses, with their extraordinarily com-

plex one, belong to the same order and should be affected by the same fundamental biological principles. If a special entelechy is required to explain the comparatively simple horse phylogeny, we should need another polyphyletic entelechy to account for the complex rhinoceros family tree, and we should, I suppose, also expect several run-of-the-mill daemons to account for more typical phylogenies of intermediate type. Anyone who believes that such logomachy explains anything is, of course, welcome to any satisfaction he derives therefrom. It seems, however, as if phylogenies, like many other summations of a large number of variables, fall into a normal curve of distribution with few either really simple or remarkably complex, but most of them of about average complexity.

Let us trace some of the main trends in rhinoceros evolution. The primitive stem group, the Hyrachyidae, springing from a common stock close to the ancestry of the horse, represents an Eocene adaptive radiation of the ancestral or, more probably, near-ancestral stem rhinoceroses. They ranged from the size of a wolfhound to that of a mustang and were moderately cursorial. The molars were only subrhinocerotic.

The hyracodonts are an Eocene-Oligocene line with fully rhinocerotic cheek teeth, but otherwise not enormously modified from the hyrachyid condition. They are slightly more specialized for cursorial life and roughly parallel the contemporary horses. It is a plausible assumption that the hyracodonts succumbed to competition with their rivals.

The amynodonts have generally been recognized as a well-defined taxonomic group, now usually given family rank. They become, progressively, more heavily built, more specialized for semiaquatic life in hippopotamus fashion, and more achondroplastic. Although it seems surprising that achondroplasia should ever evolve, achrondroplastic strains of fishes, cattle, cave-bears and bull-dogs have actually maintained themselves for varying periods. The teeth show progressive atrophy of the incisors and premolars and hypertrophy of the canines and molars, with what simulates a plastic deformation of the molars by bucco-lingual

		California		Great Plains and Rocky Mountain Basins	
Oligocene	Whitneyan	No amynodonts known			
	Orellan			Orella	Upper *Metamynodon* sp., cf. *planifrons* but more advanced Lower *Metamynodon planifrons*
	Chadronian			Chadron	*Metamynodon chadronensis*
Eocene	Duchesnean	Sespe	*Amynodontopsis bodei*	Duchesne River	*Amynodon*, n. sp., intermediate between *A. intermedius* and *M. chadronensis* C *Amynodon intermedius* intergradation
	Uintan		*Amynodon* sp.	Uinta	B *Amynodon advenus* and *A. reedi* A *Amynodon advenus*
	Uintan or Bridgerian or transitional	Poway	*Amynodon reedi*		
	Bridgerian Wasatchian	No amynodonts known			

squeezing, with some antero-posterior shear, and hypsodonty of the external margins of the molars, the whole being a remarkable parallel to the extinct South American astrapotheres.

This table shows the stratigraphic distribution of all known American amynodonts. No intergradation has been observed in this sequence, except between *A. advenus* and *A. intermedius*, where there is either stratigraphic or morphologic intergradation, according to one's concept of what a species is in paleontology. That is, if species are defined strictly by their morphology, one stray *A. intermedius* is known from Uinta B and several members of *A. advenus* have been collected from a quarry in Uinta C. On the other hand, if species are defined partly in terms of their geologic levels and (purely theoretical) breeding opportunities, then the two species in question can be separated stratigraphically but overlap somewhat in structure. It follows logically that if the question of what is a "real" species has become so nearly meaningless in paleontology, the question as to what is a "real genus" is several degrees less tangible. The only useful criterion to follow is the greatest convenience of the greatest number. There is virtually a unitary succession of progressively more specialized types at each ascending geologic level. Except for the occurrence of *Amynodon reedi* (the most primitive species) in Uinta B as well as in the probably earlier Poway conglomerate of California, and the aberrant Californian genus, *Amynodontopsis*, this series is a made-to-order example to prove orthogenetic evolution. I know of no similar authentic case so completely devoid of side lines, in the whole field of paleontology, in which an internal perfecting principle seems so clearly at work. Although I see no compelling evidence in favor of orthogenesis, I present this striking case of predetermined evolution working through the stages of racial youth, maturity and old age to the predestined doom of racial senescence and extinction. However, any mystical interpretation of the monophyletic American series must also necessarily take account of the entirely different evolutionary pattern found in the Mongolian amynodonts. Preliminary study of the extensive American Museum collection shows a very different state of

affairs—a complex, polyphyletic type of evolution diverging into numerous lines, which frequently parallel each other and the American amynodonts, forming five main autochthonous lines (if "main" is an appropriate term) during the upper Eocene and the Oligocene, in addition to an undescribed species of *Metamynodon*, presumably an immigrant from North America. The only forms yet described are the relatively primitive *Amynodon mongoliensis* and the so-called "*Cadurcotherium*" *ardynense*, a rather specialized form.

I prefer a strictly neo-Darwinian interpretation along the lines under exploration by Fisher and Wright. That is, a finite but extremely large number of mutations are potentially possible for any particular stock at any one time. Of such chemically possible mutations as may actually happen to occur, the vast majority prove to be anatomically or physiologically maladjusted and, hence, are unable to become widely established in the population. The residue, which, while proportionately a small number, would normally be a large absolute number, represent the possible next steps in evolution. Whether a given population follows one trend or several, or many divergent trends, would then largely depend on whether one chemically possible and genetically not too improbable line of evolution is sufficiently superior adaptively to its competitors to eliminate them promptly (for example, before they get far enough for their fossil remains to be likely to be found and recognized by paleontologists), or whether several or many alternative evolutionary lines are about equally efficient in maintaining themselves, especially by occupying non-competitive ecologic niches.

The gigantic Asiatic baluchitheres became the largest known land mammals, standing several feet higher than the largest elephant. The third metapodials are more enlarged, relative to the second and fourth, than in any other rhinoceros. *Forstercooperia* was recently described from the upper Eocene Irden Manha formation of Mongolia as a possible ancestor.

Eocene true rhinoceroses have been reported from both Europe and North America, but, so far, either the classification,

age, or both, have been challenged. One general common stock of hornless cursorial true rhinoceroses is found in the early Oligocene of both Europe and North America, represented by numerous forms, sometimes closely related, which are usually called genera. *Trigonias* is the best known of the more primitive forms. The manus is tetradactyl, and up to 42 teeth may be present in the jaws. Unsupported dogmatic statements have been made that this geographic distribution proves that the original true rhinoceroses were old world forms and spread thence to the new world, or vice versa, or that they must have lived in Asia and simultaneously invaded Europe and North America. Any of these statements go beyond the data, but Europe and North America were occupied by one common stock, wherever it may have originated. From then on, the most striking process was evolution in place.

The following series are probably valid or nearly so:

NORTH AMERICA

Lower Miocene (various formations and regions) —*Diceratherium armatum* (horns in male)

moderate change

Oligocene
- Upper—Whitney member of Brule —*Subhyracodon tridactylus* (horn nubbins sometimes present, probably in male)
  - intergradation
- Middle—Orella member of Brule
  - upper —*Subhyracodon "metalophus"*
  - intergradation
  - lower —*Subhyracodon occidentalis*
- Lower—Chadron formation
  - intergradation
  - upper —*Subhyracodon copei*
  - no intergradation
  - middle—*Trigonias* (probably not the direct ancestor)
  - lower —?

Once more, the intergradation which occurs here can be described as anatomical or stratigraphic. That is, if all the individuals at one level are called a "species," successive species overlap somewhat structurally; or, if "species" are defined structurally, they overlap somewhat stratigraphically. *Diceratherium* left no known descendants. However, the later American rhinoceroses, *Aphelops* and *Peraceras* (but not *Teleoceras*) may have descended from *Subhyracodon.*

EUROPE AND ADJOINING TERRITORY

		European dicerorhines	Aceratheres
Pleistocene	Magdalenian, Moustierian	*Coelodonta antiquitatis*	
	Acheulean	*"Dihoplus" mercki*	
		intergradation reported	
	Chellean	*"Dihoplus" etruscus*	
	Sicilian	*"Dihoplus" etruscus*	
Pliocene	Astian	*"Dihoplus" leptorhinus*	
	Plaisancian	*"Dihoplus" leptorhinus*	
	Pontian	*"Dihoplus" schleiermacheri*	*Aceratherium incisivum*
Miocene	Vindobonian	*"Dihoplus" hispanicus*	|
		"Dihoplus" simorrensis	*Aceratherium tetradactylum*
	Burdigalian	*"Dihoplus" sansaniensis*	|
		"Dicerorhinus" tagicus	*Accratherium depereti*
	Aquitanian	*"Dicerorhinus" tagicus*	|
			Aceratherium lemanense
Oligocene	Upper Stampian		|
		"Dicerorhinus" tagicus tolosanus	*Aceratherium lemanense*
	Middle Stampian	*Protaceratherium albigense*	

The nomenclature of the European dicerorhines is in chaotic condition and the particular names here recognized could be criticised very readily. However, the succession itself seems to be real. The acerathere series is slightly modified from the long-cited sequence.

In a number of cases (e. g., *Amynodon* in the upper Eocene of Asia and North America), intercontinental migration of some sort must have taken place. There are also a large number of dubious cases. But in only one case so far published is it possible to demonstrate the direction of migration. The genus *Brachypotherium* is represented by successively more specialized species from the earliest Miocene into the Pliocene of Eurasia and north Africa. A direct derivative, *Teleoceras*, appears in the upper Miocene of North America and extends through the lower and middle Pliocene, represented by successively more specialized forms. So similar is a primitive *Teleoceras* to a moderately specialized *Brachypotherium* that assignment between the two genera is based simply on locality, so that essentially indistinguishable specimens from Japan and Nebraska have been assigned without objection to *Brachypotherium* and to *Teleoceras* (*Mesoceras*).

Students of migration have frequently commented upon two striking and unexplained failures to grasp available opportunities.

When, in the Pliocene, the Panama land-bridge was reestablished, rhinoceroses did not accompany horses, elephants and tapirs across it into South America, although they survived long enough to coexist with northwardly migrating ground sloths in at least four middle Pliocene (Hemphillian) local faunas in the United States. No one has ever understood why the woolly rhinoceros did not accompany the boreal mammoth across the Siberia-Alaska bridge into North America in the Pleistocene. No explanation can be assigned for the latter failure, since the bridge should have been a "corridor" for both, and only the elastic formula, climatic barrier, for the first. The failure of the Pleistocene elasmotheres to reach North America is less surprising, since they seem to have been restricted to the middle latitudes and may not have ranged far enough north to have been able to use the bridge.

The rhinoceroses show interesting examples of parallel and convergent evolution. Compare the familiar evolution of horse cheek teeth with the progressive development of comparable plications and hypsodonty in the cheek teeth of the extinct elasmotheres of Eurasia. The end stage almost exactly mimics the horses, or even out-horses them, in the length of crown and the lateness of the development of roots (thus closing the pulp cavity); each tooth having become a complicated, high-crowned, grinding mill with alternating areas of enamel, dentine and cement. Nevertheless, this end stage is still a gloss on the fundamental rhinoceros pattern, representing a Greek letter *pi* in the upper molars and two sharply asymmetrical crescents in the lower molars, and never acquired a true horse pattern. Although this convergence extends only to the cheek teeth, it is quite clear that one or both are guilty of flagrant plagiarism. The end stage (*Elasmotherium*) was the largest of all rhinoceroses except the baluchitheres and bore a single enormous frontal horn. The elasmotheres were, for most of the time since their discovery, a "great unknown," and have been assigned relationship to edentates, carnivores and aquatic mammals.

Parallel evolution also occurs among the rhinoceroses. One

of the most striking cases is the resemblance between the extinct woolly rhinoceros of the Eurasiatic glacial period and the living white African rhinoceros, in size, body shape, horns and hypsodonty. Compare, also, the Dordogne cave engraving with rock carvings by African bushmen. So close a resemblance has usually been interpreted as due to direct descent, the white rhinoceros being considered a southern survivor of an extinct northern relative, just as the African hippopotamus is considered a little changed representative of the Pleistocene hippos of Europe. However, the evidence now justifies the conclusion that the woolly rhinoceros was, as previously indicated, the terminal member of a northern line of Sumatran rhinoceroses represented in each successive level of the later Cenozoic of Europe, while the white rhinoceros appears to be a more specialized, grazing relative of the existing African black rhinoceros, with an autochthonous African line of evolution, which, although largely unknown, must have been fairly distinct from the line leading to the woolly rhinoceros. This particular case of parallelism is almost as well documented anatomically as if both forms were extant, since the woolly rhinoceros is known not only from abundant ordinary skeletal remains, but also from five "cold-storage" carcasses from Siberia and two eviscerated carcasses from Galicia, "pickled" in brine and hydrocarbons.

The scientific validity of family trees has often been challenged. Inevitably, they suffer from oversimplification. Conversely, it is sometimes charged that they embody artificial complications, such as the theoretical descent of imaginary groups based on taxonomic recognition of the extremes of individual variation found at successive levels, with imaginary genetic relationship of these extremes. With all allowance for the only too frequent validity of both criticisms, there is, nevertheless, a considerable field of usefulness for carefully drawn family trees, and I know of no alternative which permits the expression of data in more significant and usable form. As a check, I reexamined the older rhinoceros family trees. The first, Cope's tree, dating from 1879, is essentially a comparative anatomy diagram without

detail. The first detailed phylogenies, Gaudry's of 1888 and Pavlow's of 1892, are more readily compared with modern views. Although there are great differences, particularly in the enormous expansion of the American record and in the completely new record from eastern Asia, whole sections from the European parts of Gaudry's and Pavlow's trees survive in my phylogeny with little change. A later, more balanced treatment of new and old world forms will be found in Osborn's 1905 phylogeny, which summarizes the results of his concentrated work on rhinoceroses, and in his unpublished 1926 phylogeny, which is partly a compromise with my views of that time. Matthew, in 1931 and 1932, expressed considerable disagreement with Osborn and with Wood. Nevertheless, there is a fair measure of essential agreement, aside from temperamental differences as to what to call things. My last effort at a phylogenetic tree has not been published and already seems out of date and amateurish. Nevertheless, most of it would appear without essential change in any revised version. It, therefore, seems that, when one related species follows another in ascending stratigraphic sequence in a natural geographic region, this may approximately represent the real succession, and further discoveries are more likely to confirm than to overturn this conclusion. On the other hand, a series based on scattering forms with no logical stratigraphic or geographic relation to each other should be regarded as only a morphologic series comparable to those studied by a student in comparative anatomy and, hence, as likely to suffer extreme reinterpretation as additional data accumulate.

Many problems are still to be solved. Besides working out, in greater detail, questions for which the probable solution is already indicated—"carrying it out to another decimal point"—the following are a few obvious ones:

1. The exact ancestry of the rhinoceroses in general and their exact relationship to other primitive perissodactyls.
2. The exact ancestry of the amynodonts, of the baluchitheres, and of the true rhinoceroses (Rhinocerotidae).

3. The ancestry of certain late American forms (*Aphelops* and *Peraceras*). Whether autochthonous evolution, immigration, or both are hereafter demonstrated, the answer will be equally interesting.
4. The ancestry of the living African rhinoceroses. Essentially indistinguishable forms have been reported in the African Pleistocene. The only earlier hint is *Diceros* (?) *pachygnathus* from the Pontian of Pikermi. A still earlier ancestry from American forms or their old world relatives is conceivable, but hypothetical to an extreme.

The future of the rhinoceroses seems dark indeed. In the past, they occupied every continent except Australia and South America, but their range has been shrinking rapidly for the last few million years. The last American rhinoceroses, *Aphelops* and *Teleoceras*, date from the middle Pliocene. In Europe, rhinoceroses survived to the end of the Pleistocene and were represented by Crô-Magnon artists. Although the reactions of early man to rhinoceroses are thus preserved, we have no data on the converse reaction. Judging from the behavior of their living relatives, it was probably a blind charge or an equally panicky flight. Rhinoceroses survived in south China down to the historical period, perhaps to 200 A. D. or even, by one account, to a thousand years later. Linnaeus, with less than his usual acumen, classified the Indian rhinoceros as a rodent. But, two centuries earlier, the Mogul conqueror of India, Babur (or his literary "ghost"), concluded that the rhinoceros resembled the horse more than any other animal, especially in stomach and foot. At that time, rhinoceroses were abundant across northern India, down the Malay Peninsula and in Sumatra, Java and Borneo. At about the same time, the first African explorers found rhinoceroses abundant south of the deserts and west to Nigeria. Since then, rhinoceroses have not bowed to the increasingly tyrannical human domination of the land surface of the earth, and three centuries of close settlement and sportsmen have restricted the white rhinoceros to the game reserve in Zululand and to the Lado-Uganda region of equa-

torial Africa, with a hundred or so individuals in each area. The black rhinoceros, still reasonably abundant in parts of south, central and east Africa, has been considerably restricted in range. Due to their financial value for "medicinal" purposes, all three Asiatic species are on the verge of extinction, according to the game wardens. Perhaps less than a dozen individual Javan rhinoceroses are still alive, and perhaps a hundred Indian rhinoceroses, while living Sumatran rhinoceroses would more probably be numbered in hundreds than in thousands. The situation is made more hopeless by the fact that the Asiatic species are now restricted to such sparse numbers scattered over such large areas that there is progressively less chance for males and females to encounter each other.

The so-called Pleistocene extinction, affecting large mammals almost exclusively, is still continuing more rapidly than ever before. Whatever was the case in the earlier stages, at the present time there is little question that man is the effective agent. Unless a really determined effort is made, there seems little hope that any except the black rhinoceros can be preserved into another century; and its extermination, although a little further off than the rest, also is probably inevitable. A specialist on the group naturally regrets their impending doom, but admittedly they are stupid animals, and, from a human view-point, antisocial. Perhaps, instead of deprecating their approaching extinction, we should recognize our good luck that a group, which might well have been exterminated in the prehistoric past, has survived to the present day to help interpret the remains of their fossil relatives and ancestors.

SECTION OF PSYCHOLOGY

JANUARY 20, 1941

PROFESSOR KIMBALL YOUNG, Queens College, Flushing, New York City; *A Preliminary Report on a Field Study of Farmers' Attitudes.*

This was a tentative report of a research project set up by the Division of Farm Population and Rural Welfare of the Bureau of Agricultural Economics, Department of Agriculture, designed to secure information on the attitudes and values of a selected sample of American farmers. The objective of the study as stated in the original plan was as follows: "To investigate the cultural, community, and social psychological factors in land use and rural life, with special reference to those factors which either facilitate or offer resistance to change, contribute to adjustments and maladjustments, and to stability and instability in the individual or community life." The planning and execution of this project was carried out by a group of experts in social psychology, rural sociology, and cultural anthropology. The full reports on this research will be published by the Bureau of Agricultural Economics.

In presenting his preliminary report, Dr. Young discussed chiefly the methodology with only a brief comment on some of the major findings. The completion of the investigation is still some months away.

SECTION OF ANTHROPOLOGY

JANUARY 20, 1941

DOCTOR GEZA RÓHEIM, New York, N. Y.: *Yaboaine, A War God of Normanby Island.* (No abstract has been received by the Editor.)

SECTION OF PHYSICS AND CHEMISTRY

FEBRUARY 10 and 11, 1941

Conference on "*X-Ray Diffraction*"

The Section of Physics and Chemistry held a Conference on "X-Ray Diffraction," the second of the series this year. Doctors A. L. Patterson, Bryn Mawr College, and B. E. Warren, Massachusetts Institute of Technology, were in charge of this meeting as Conference Chairmen.

The program consisted of the following papers:

I. EXPERIMENTAL PROBLEMS INVOLVED IN THE COLLECTION OF DATA

I. 1. "Introductory Remarks on Apparatus and Techniques." B. E. Warren, Massachusetts Institute of Technology.

I. 2. "Production of Monochromatic Radiation." S. B. Hendricks, U. S. Dept. of Agriculture, Washington, D. C.

I. 3. "Diffraction Apparatus and Techniques." M. J. Buerger, Massachusetts Institute of Technology.

I. 4. "Measurement and Correction of Intensities." I. Fankuchen, Massachusetts Institute of Technology.

II. INTERPRETATION OF DATA

II. 1. "Introductory Remarks, Including Outline of Fourier Series Methods." A. L. Patterson, Bryn Mawr College.

II. 2. "Computation of 2-dimensional Fourier Series. G. Tunel, Geophysical Laboratory, Carnegie Institute, Washington, D. C.

II. 3. "Optical Synthesis of Fourier Series." M. L. Huggins, Eastman Kodak Company, Rochester, N. Y.

II. 4. "Diffraction Synthesis of Fourier Series." M. J. Buerger, Massachusetts Institute of Technology.

II. 5. "Interpretation of X-ray Diffraction Data by means of Fourier Series." D. Harker, The Johns Hopkins University.

III. DIFFUSE SCATTERING

III. 1. Introductory Remarks. P. Debye, Cornell University, Ithaca, N. Y.

III. 2. "Temperature Diffuse Scattering." W. H. Zachariasen, University of Chicago, Chicago, Illinois.

III. 3. "Diffuse Scattering of X-rays from Layer Lattices." S. B. Hendricks, U. S. Department of Argiculture, Washington, D. C.

IV. General Discussion

Questions of organization and publication of diffraction results. M. L. Huggins and M. J. Buerger.

Doctor Barnum Brown, The American Museum of Natural History, New York, N. Y.: *The Methods of Walt Disney Productions.* (An extended abstract of an address given at the Annual Dinner and Meeting, December 11, 1940.)

Having seen a portion of Fantasia, this audience will no doubt be interested in knowing something of the basic foundation on which this marvelous animated picture was created.

About three years ago, I had considerable correspondence with the Walt Disney Studios about dinosaurs, as to typical forms in the different geological periods, their history and relationship, the various kinds of life that could be associated with dinosaurs during the period of their existence, and the more primitive species that preceded the era of dinosaurs.

On the basis of these data, as well as models, restorations, etc., furnished through my efforts, a number of artists in the Walt Disney Studios proceeded to make scenes representing the dinosaurs and other typical associated reptiles. The plan was to run a continuous story from the beginning of life on this planet up to the close of the dinosaur era, which it was proposed to make the climax of the picture.

When a great many drawings had been made, I visited the Disney Studios and found their walls covered with very creditable and accurate types of prehistoric life including the associated floras. I made whatever constructive criticisms were necessary for the further development of the story. Naturally, there were many different groups involved in this story, and while material was not available for a continuous sequence, much of the prehistoric life was well represented.

In most of the scenes, the restorations of the creatures were generally not as exact as the scientist would require, but it should be borne in mind that in an animated picture of this kind it would have been impossible to have faithfully copied the accurately

worked out material used in the studio as a control. Therefore, most of the creatures as now shown are necessarily conventionalized.

In the meantime, while different sequences were being created in drawings, Walt Disney, Deems Taylor, and Leopold Stokowski selected eight outstanding musical compositions that, in their opinion, could be coordinated with corresponding sections of the spectacle to best represent the action, after which the Philadelphia Symphony Orchestra played the entire program through, making a recording of 450,000 feet of film. This was cut to the 18,000 feet used during the time that the complete spectacle of FANTASIA is shown, but so skillfully that few, except experts, in any audience would realize that there has been any material loss in the compositions. In the Rite of Spring, by Igor Stravinsky, which was selected to accompany the theme embodied in the creation of the world and the evolution of the dinosaurs, only expert scientists would realize any major imperfections in the scenes as they progress on the screen.

Few of us, who have had the privilege of watching volcanic eruptions, can recall any volcanoes as active as those you have just seen, and yet the principles of vulcanism have been well shown, and, to most of the audience, the accompanying music has to a degree typified the effect.

Thus, Walt Disney has taken the findings of the scientist to show the culmination of dinosaur life through change of environment and their final extinction through their lack of capacity to adapt themselves to this type of life, or to seek, by migration, conditions that were favorable for the continuance of their existence.

These conditions were illustrated and emphasized by the results of one of our recent expeditions, during which the remains of a herd of dinosaurs were found in an ancient lake bed in the Big Horn Basin of Wyoming. Here, many dinosaurs had congregated in the fast receding lake bed, where they had all died in their tracks.

Several other incidents in this portion of FANTASIA harmonize with the findings of Museum expeditions.

In the presentation of FANTASIA, many new features of sound production and dispersal have been created and it will exemplify the remarkable progress of motion picture animation to date. Walt Disney and his more than 1200 associates, who at some time have worked on parts of this picture, are to be congratulated on a marvelous achievement in the picturization of interesting and fascinating features of animal life, accompanied by music that harmonized with the scenes portrayed. As some one has aptly said, "It more nearly represents hearing pictures and seeing music."

This Walt Disney production is a distinct contribution from an educational standpoint in the field of motion picture animation, showing as it does, the accepted course of major features of the development of the earth and the evolutionary trends of life during successive geologic periods, accompanied by appropriate classical musical compositions.

It is very gratifying to have returned from Texas in time to enjoy this presentation of The Rite of Spring from FANTASIA with the Academy and its guests this evening, and it is an especial pleasure to be able to show you some scenes from our recent field work, which resulted in much new information relating to our friends, the dinosaurs.

Last May, arrangements were made with the Sinclair Refining Company for financing an expedition for dinosaurs into the Big Bend area of Southern Texas, where dinosaurs were first reported by me in 1911. This fund was also to be used, in part, to cover transportation charges on the large series of fossil sauropod tracks excavated by Mr. R. T. Bird on a W. P. A. project in central Texas, which started in April.

Doctor Erich M. Schlaikjer, who was to assist me in the early part of the Big Bend work, left New York, July 30, for Rock Springs, Wyoming, where our truck was stored, and drove through to Glen Rose, Texas, where the tracks were being excavated, and I joined him there on August 8.

We proceeded to Marathon, Texas, making that town headquarters, and drove south 100–150 miles to the Cretaceous Bad

Land exposures that surround the Chisos Mountains. In 1939, Doctor Schlaikjer had located several specimens in this area, during a reconnaissance trip. We examined these first and then investigated different parts of the exposures for the purpose of determining in what area dinosaur remains were best preserved. It soon became evident that associated material was rare in the entire area and specimens worth excavating were rarer still, although fragments and incomplete dinosaur bones were found literally by the thousands, wherever there were good exposures.

The Aguaja formation in which Cretaceous dinosaurs are numerous is 220 feet in thickness in several measured exposures. These beds overlie the strictly marine Boquilla beds and, in turn, are comformably overlain by a series of Cretaceous clays 1600 feet thick, known as the Tornillo beds, in which only sauropod dinosaurs are found.

While Doctor Schlaikjer was with me, we covered the Aguaja beds east, south, and west of the Chisos Mountains, taking up several specimens and locating others that were excavated later.

In the meantime, Mr. Bird completed the excavation of the dinosaur tracks at Glen Rose and crated a part of them before joining me on September 10, when Doctor Schlaikjer returned to New York.

We completed the Big Bend dinosaur work, November 30, shipping the collection from Alpine and Marathon to Walnut Springs, the rail point for Glen Rose. We then took a short trip into Mexico at Presidio but found only marine exposures and no dinosaur-bearing beds south of the Rio Grande. From Presidio, we followed the Rio Grande northward on the Texas side in search of reported fossiliferous Tertiary strata.

North of Newman Springs, approximately 16 miles southeast of Porvenir, we found an extensive thick exposure of Tertiary strata thought to be Oligocene in age, covering a considerable area, in which a few bones and teeth of mammals were collected. Titanotheres, and also *Dinictia*, *Mesohippus* and *Oreodon*, have been found there. These exposures have been worked, though not exhausted, by the University of Oklahoma and are worthy of more extensive search.

A new chapter in our dinosaur work has been added as a result of the American Museum of Natural History—Sinclair Expedition to the Big Bend area. This is the most southern point in the United States where dinosaurs have been found. In all, eleven important specimens were excavated in this region, among which the following are the most noteworthy:

An incomplete but enormous crocodile skull having teeth three inches long and one inch in diameter (probably *Dinosuchus*), which was as large as a medium-sized dinosaur;

A disarticulated skull with associated limb-bones of a small ceratopsian, resembling and closely related to *Brachyceratops;*

Another incomplete ceratopsian skull, tentatively referred to *Pentaceratops;*

A ceratopsian pelvis, sacrum, and part of the dorsal series with ribs attached (probably *Pentaceratops*), which was the only articulated specimen found;

A complete skull of a new genus and species of a plated dinosaur resembling *Palaeoscincus.*

The dinosaurs collected by us and specimens seen in other collections at El Paso and the Oklahoma University represent a faunal facies comparable in age to that of the Judith River and the Mesa Verde Cretaceous of northern states, but most genera and probably all species are new to science. Two very large sauropod bones—a humerus and a cervical vertebra (*Alamosaurus*)—were excavated from the Tornillo beds, the vertebra being the largest cervical that has been recorded.

The sauropod dinosaurs found in the Tornillo beds show that climatic conditions favorable for the life of sauropods persisted in this southern region millions of years after that group of dinosaurs had become extinct in the northern states.

From the Palaeozoic and Mesozoic strata examined, many invertebrate specimens were collected, some being of unusual exhibition value.

Leaving Marathon, November 8, we drove 500 miles to Glen Rose, where the track specimens were crated and hauled to the railroad at Walnut Springs, the season's collection aggregating a carload of 44,000 pounds.

The rare sauropod track collection, made possible through W. P. A. assistance, has great value for our exhibition halls, for, with the trail of fore and hind feet displayed under the tail of the *Brontosaurus* skeleton already there, they will form a convincing record of the position and movement of the limbs of these creatures, when in motion,—our first definite evidence for the exact placement of the fore limbs in sauropod skeletons.